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WASTEWATER ENGINEERING AND MANAGEMENT PLAN FOR BOSTON HARBOR - --ETC(U)

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WASTEWATER ENGINEERING AND MANAGEMENT PLAN

FOR

BOSTON HARBOR - EASTERN MASSACHUSETTS METROPOLITAN AREA

EMMA STUDY

TECHNICAL DATA VOL. 11

NUT ISLAND WASTEWATER TREATMENT PLANT ANALYSIS AND IMPROVEMENTS

OCTOBER 1975

INDEX TO EMMA STUDY REPORTS

COVER PHOTO

Aerial photograph of the Nut Island Wastewater Treatment Plant - 1972.

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WASTEWATER ENGINEERING AND MANAGEMENT PLAN FOR BOSTON HARBOR – EASTERN MASSACHUSETTS METROPOLITAN AREA EMMA STUDY

TECHNICAL DATA [redacted] Volume 11.
NUT ISLAND WASTEWATER TREATMENT PLANT ANALYSIS AND IMPROVEMENTS

FOR THE

METROPOLITAN DISTRICT COMMISSION

COMMONWEALTH OF MASSACHUSETTS

BY

METCALF & EDDY, INC.

410 091

11 OCTOBER 1975

12 63p.

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CHAPTER 1

INTRODUCTION

General

In investigating wastewater management plans for the Eastern Massachusetts Metropolitan Area, five basic conceptual plans were considered. These are described in detail in Technical Data Vol. 4 and 5. After reviewing the findings of this investigation and holding a series of public meetings, the Technical Subcommittee recommended the construction of two satellite plants within the service area of the Nut Island Treatment Plant. One of these satellite plants would be located in the Upper Neponset River Watershed, and the other in the Middle Charles River Watershed. The construction of these plants would materially reduce the tributary area served by the Nut Island Wastewater Treatment Plant.

The plant now serves a population of 634,000 which, because of the reduced service area, is not expected to increase much beyond 670,000 people by 2000. For this reason, and because the areas served have essentially reached their limit of growth, it is not anticipated that the average daily wastewater flow into the plant would appreciably increase over the design period. Accordingly, it can be expected that any major plant expansion requirements would arise from the higher treatment requirements.

Report Structure

As shown on the inside cover, the study results are presented in a series of volumes.

This report is Technical Data Vol. 11, Nut Island Wastewater Treatment Plant Analysis and Improvements and covers the study performed to analyze the necessary improvements to the primary treatment facilities at the Nut Island Wastewater Treatment Plant, together with the work necessary to provide secondary treatment capabilities at the facility.

The introductory chapter is followed by a discussion of the existing primary facilities at Nut Island. Chapters 3 and 4 present and discuss the basic design criteria and those facilities that would be required to attain an upgraded primary plant and a secondary treatment facility, respectively. Alternative arrangements are discussed and a

selected plan is developed and costed in Chapter 5. A phasing program for the selected plan is developed in Chapter 6.

Appendix A lists the principal equipment (three pages). Appendix B is a report of an inspection of the main pumping station by Mr. Allen J. Burdoin in 1973 with recommendations (3 pages). Appendix C is a detailed inventory of the Nut Island facility (115 pages).

Due to the nature and length of this invetory, it has not been included in every copy of the report. However, in order to acquaint the reader with its content, the first sheet of the inventory is included. A complete copy of the inventory is available for review at the Metropolitan District Commission.

CHAPTER 2

EXISTING FACILITIES

General

The Metropolitan Sewerage District is generally referred to in terms of two subdistricts; the North Metropolitan Sewerage District and the South Metropolitan Sewerage district. The wastewaters generated within the South Metropolitan Sewerage District are conveyed to the Nut Island Treatment Plant where primary treatment is provided before discharging it to Boston Harbor. The plant serves an area of approximately 238 square miles, which contains 21 cities and towns, including portions of Boston, Brookline, Milton, and Newton. In 1971, this area contained a population of 773,000 of which approximately 634,000 are presently (1974) served by the Metropolitan sewerage system.

Plant Description

The Nut Island Treatment Plant was designed for an average daily flow of 112 mgd (million gallons per day) and a peak flow of 300 mgd. A flow diagram of the plant is shown on Figure 2-1. As indicated on the diagram, wastewater from the High Level Sewer passes through bar screens, grit chambers and comminutors and is then pumped to the preaeration tanks. Wastewater then flows by gravity through the primary tanks and the outfall system. The outfall system discharges to Nantasket Roads in the Outer Harbor. The outfall system, including an emergency overflow outfall, has a design capacity of 300 mgd at the highest tide of record (El 115.7 MDC Datum).

The Nut Island Treatment Plant consists of two bar screens, six grit chambers, nine communitors, four mixed-flow sewage pumps, five preaeration tanks, six primary settling tanks, and four digestors. Sizes and capacities of the principal plant equipment are presented in Appendix A.

An engineering evaluation of the main pumping station is presented in Appendix B.

A detailed inventory of the existing plant equipment was made as part of this investigation. The inventory is presented in Appendix C.

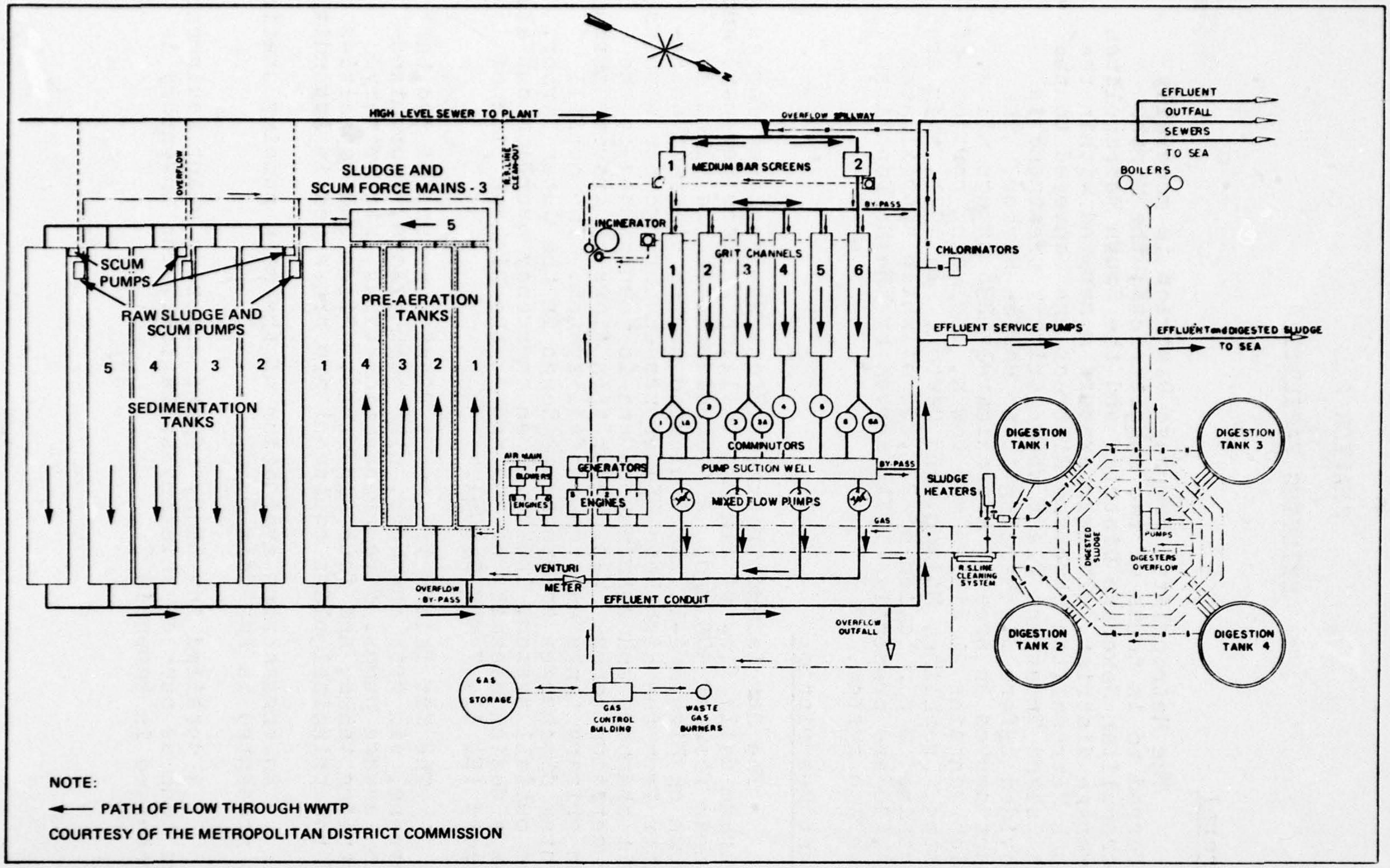


FIG. 2-1 FLOW DIAGRAM NUT ISLAND WASTEWATER TREATMENT PLANT

Plant Operations

Approximately 76 positions are allocated for the personnel to operate the plant. Of these, six undertake administrative and general office work, 32 are assigned to operations, 33 are employed to maintain the plant, and five provide laboratory control.

A partial summary of operational data for the period of July 1, 1973 to June 30, 1974 is presented in Table 2-1.

Adequacy of Existing Facilities

The Nut Island Treatment Plant was placed in operation in 1952 and it can be anticipated that much of the original mechanical equipment, if it has not already been replaced, will require renewal in the near future.

The condition of the existing equipment as noted in this chapter is based on the inventory survey which is presented in Appendix C, plant inspections, interviews with plant staff, and review of previous reports concerned with the condition of the existing equipment at the plant.

Preliminary Treatment

The preliminary treatment facilities at Nut Island consist of bar screens, grit chambers and comminutors. The equipment associated with these facilities with the exception of the bar screens are in good condition. The bar screens are subjected at times of high flows to excessive impact from solid objects due to the high velocities in the approach channels. This excessive impact has on occasion bent the bars on the bar screens.

General debris and grit removed by the bar screens and grit chambers is pneumatically conveyed to an incinerator. The incinerator is a six multiple-hearth incinerator. The system performs well and should be retained.

The general arrangement of the preliminary treatment facilities is adequate, although some flow regulation is required to distribute the flow equally between the existing six grit chambers. It is reported that the grit chambers operate satisfactorily when handling flows up to 210 mgd. At greater flows, grit is carried over into the preaeration tanks. Also, at flows in excess of 210 mgd, some of the comminutors become surcharged and a system of retaining baffles has been installed to prevent solids from passing directly into the pump wet well.

TABLE 2-1. SUMMARY OF OPERATING DATA

Gallonage[1]	
Sewage flow, mgd, average	139.28
Sewage flow, mgd, maximum	208.95
Grit	
Removed, cf, total	32,433
cf, mil. gal	0.64
Volatile content as collected, percent	24.9
Screenings	
Removed, cf, total	13,991
cf, mil. gal	0.28
Incinerator ash, percent volatile	0.0
Suspended solids[2]	
Influent, ppm	250
Effluent, ppm	114
Removal, percent	54
Settleable solids	
Influent, mg/L	7.9
Effluent, mg/L	0.4
Removal, percent	94.9
BOD_5[3]	
Influent, ppm	124
Effluent, ppm	88
Removal, percent	29.0
lb/day	41,840
Grease, pet. ether, soluble	
Influent, ppm	44.8
Effluent, ppm	24.4
Removal, percent	45.5
Chlorine requirement (demand)[4]	
Influent, ppm	7.8
Effluent, ppm	7.0

TABLE 2-1 (Continued). SUMMARY OF OPERATING DATA

Chlorine residual	
Effluent, ppm, orthotolidine	1.0
Days maintained	365
Bacterial concentration	
Influent, 100 ml	14,700,000
Effluent, 100 ml	1,600
Removal, percent	99.92

1. Does not include quantity lost during 72-day period of partial spillover of excess stormwater beyond capacity of available plant equipment.
2. Twenty-four-hour automatic samplers out of service for five months, September through January. Samples taken manually during this period.
3. Influent under influence of prechlorination for six months.
4. Includes effect of prechlorination rates of 2,000 - 3,000 lb/day.

Influent Pumps

The influent pumping station was designed to pump a peak flow of 300 mgd. To meet this design criteria, four mixed-flow vertical sewage pumps each having a rated capacity of 83.5 mgd at a discharge head of 10.3 feet were installed. Plant bypassing was allowed for by construction of a weir across the High Level Sewer which permits any flow not pumped into the plant to overflow through the outfall system. With today's treatment and design standards, bypassing of plant treatment facilities is no longer acceptable.

As noted in the inspection report presented in Appendix B, the existing pumps are those which were originally installed and are in good condition although the wearing rings may need replacement soon. This report recommends the capacity of the overhead crane be increased to facilitate the maintenance of the existing pumps and motor units.

Preaeration Facilities

There are five preaeration tanks which are equipped with swing-arm sparger-type diffusers. The diffusers appear to operate satisfactorily. However, due to advances in diffuser design, some consideration should be given to updating the aeration distribution system through the use of diffusers of more advanced design which improve the oxygen transfer rates and minimize plugging of the diffuser.

Primary Sedimentation Facilities

There are six primary settling tanks equipped with covers. All of these structures have settled to some degree. The most northerly tank (primary tank No. 1) has settled the most, with an overall average settlement of 12 inches and a maximum settlement of 24 inches.

The structural conditions of the tanks was the subject of a report prepared by The Thompson & Lichtner Co., Inc., Engineers,* in 1971. The findings of this report were based on an extensive soil investigation program, measurement of the settlement at the surface elevation of each tank, and settlement data for both the top and bottom slabs of Tank No. 2.

The report concludes in part:

1. "That the sludge collector system does not work effectively and is difficult to maintain due to the distortion in the concrete structure."
2. "That due to the distortion accompanying the settling movement, the tanks have suffered cracking, spalling and movement of various concrete slabs and walls."
3. "That the upper supports of the sludge collector system in Tank No. 3 remain relatively level, but considerably below the design water level of 122.55 for a flow of 112 mgd."
4. "The tanks do not appear to be in a structurally dangerous condition; however, the reconditioning of spalled surfaces and repairs of cracks in floors, walls must be done."

*The Thompson & Lichtner Co., Inc., Nut Island Sewerage Treatment Plant Sedimentation Tank Area Structural Conditions, June 22, 1971.

The report recommends in part:

1. "Removal of the roof of the structures and raising the height of the walls so that the sludge removal system could be reinstalled at its original design elevation with or without a roof would involve considerable danger of disturbing the soil conditions and of collapse of structures already cracked and highly stressed in some parts."

2. "We recommend since the concrete is sound that the present structures be repaired as to cracks and spalled concrete and that additional capacity be obtained by supplementing degreasing equipment and additional tanks."

A review of the data that has been made available to use relative to the settlement of the existing primary tanks leads to the following conclusion:

1. Before any final decision is reached, the settlement records of the existing tanks should be fully studied. If the records show that settlement has stopped and if the unit load in the new tanks can be restricted to no more than the existing load, no additional foundation treatment may be required if the tanks are reconstructed. Additional borings with standard penetration tests should be made to determine the present relative density of the soil.

2. The possibility of preloading and preconsolidating the site prior to reconstructing the tanks should be evaluated if new tanks are required and will impose a load greater than that of the present tanks or if the existing tanks are continuing to settle.

3. The techniques of densifying the granular soil fill underlying the present tank foundation by means of either the vitro-flotation process or the Foster vibratory probe should be investigated as an alternative to preloading.

4. If, after consideration of the above less expensive alternatives the decision was reached that a pile foundation was required, several different

types of pile systems should be considered. These are Mini-Franki, wood, and cast-in-place shell piles.

Sludge Pumping Facilities

There are three raw sludge pumping stations, each of which serves two primary settling tanks. Each station contains two positive displacement pumps and one torque flow pump. With renovation, the existing pumping facilities could be used in an upgraded facility.

Scum Collection System

The scum collection system was designed to collect scum and grease which floated on the water surface in the primary tanks in transverse channels located at the eastern ends of the tanks. These channels were equipped with cross collectors that conveyed the scum-to-scum conveyors, which in turn carried the scum to grease pits located at the raw sludge pumping stations. From the pits, the scum was pumped to the digesters. Since primary tanks No. 1, 2 and 3 had sufficient settlement to cause the collecting flights on the scum system to ride below the water surface, the scum surfacing in these tanks was never adequately collected in the transverse channels. It was also found that when the scum that was collected in primary tanks No. 4, 5 and 6 was pumped to the digesters, that there was sufficient buildup of grease in the pipelines to cause excessive maintenance problems. For this reason, the scum collection system serving primary tanks No. 5 and 6 was modified so that the cross-collection system discharged the scum to a water-grate grease burner, rather than a grease pit. This system has worked well, but is not now in operation due to the lack of available manpower. To further aid in controlling the buildup of grease in the scum pipelines, a hot water flushing system was installed which has performed well.

If the existing primary tanks are used in an upgrading situation, the existing scum collection system should be updated. Consideration should be given to the installation of helical scum cross collectors, which would drain to the main scum tanks from which the scum would be pumped to the point of ultimate disposal. Although the water-grate incinerator has worked well, it is probably not advisable to use this particular piece of equipment in an upgraded facility. This is because the existing incinerator has a limited burning capacity and has served its normal useful life.

Chlorination Facilities

The chlorination facilities consist of ton cyliners, evaporators, chlorinators, and a residual chlorine analyzer and recorder. Chlorine is applied to the influent wastewater upstream of the bar screens and to the effluent wastewater downstream of the primary sedimentation tanks. The residual chlorine recorder was initially used to control the chlorinators that feed chlorine to the plant effluent. However, due to difficulties in operating the recorder, these chlorinators are now controlled manually.

The ton cylinders are located in the Administration Building and the chlorinators and evaporators are housed in the Main Building. The general arrangement of both these facilities is neither adequate nor safe by present day standards and they should be relocated or modified as required in an upgrading situation.

The general condition of the chlorinators and evaporators is good. One of the chlorinators was part of the original installation, but a replacement unit of more modern design is already on hand to replace this unit in the event of failure. In a plant of this size, particularly if it is upgraded, the chlorine feed rate should be automatically controlled and a control system should be provided for this purpose.

The chlorine is presently received at the plant in ton cylinders since when this plant was designed, ton cylinders were the largest units that were available from chlorine suppliers. Since that time, chlorine has become available in tank truck lots and consideration should be given to developing facilities that will accommodate this mode of shipment.

Heating Plant

The main heating plant is located in the Administration Building. The heating plant consists of two boilers which were installed in 1896. These units should be replaced with a modern heating plant. The space occupied by the existing equipment will be inadequate for modern equipment of comparable capacity and any new equipment is, therefore, better located in a new operations and maintenance building.

Electrical Plant

Most of the major units of the electrical plant operate satisfactorily and are of sufficient rating for the loads imposed on them. Nevertheless, some of the major units, particularly those which were part of the original installation, should be replaced and relocated under an upgrading situation. There is need for additional conduit capacity within the plant site.

Plant Outfall System

The plant outfall system as shown on Figure 2-2 was designed to discharge to the Nantasket Roads in the Outer Harbor through two long outfalls (5,830 and 5,545 feet) and a shorter (1,412 feet) submerged outfall that was to be used in the event of extreme high tides or plant influent flows in excess of 150 to 200 mgd depending on tidal conditions. The plant is also provided with an emergency overflow weir which is located in the effluent conduit downstream from the sedimentation tanks. Discharge from this overflow weir is conveyed to the eastern shoreline of the treatment plant through a 60-inch diameter outfall. The purpose of this particular outfall is to permit the plant to continue to operate at times of extreme high tides (El 115.7 MDC datum) and plant inflows approaching 300 mgd. At such times, as much as 100 mgd of treated wastes could be discharged through this outfall to the eastern shoreline. At a tide elevation of 115.7, the terminal end of this outfall would be submerged by about 15 feet. This depth of submergence was considered adequate to sufficiently dilute the effluent wastewater to prevent the development of nuisance conditions at the time the plant was designed.

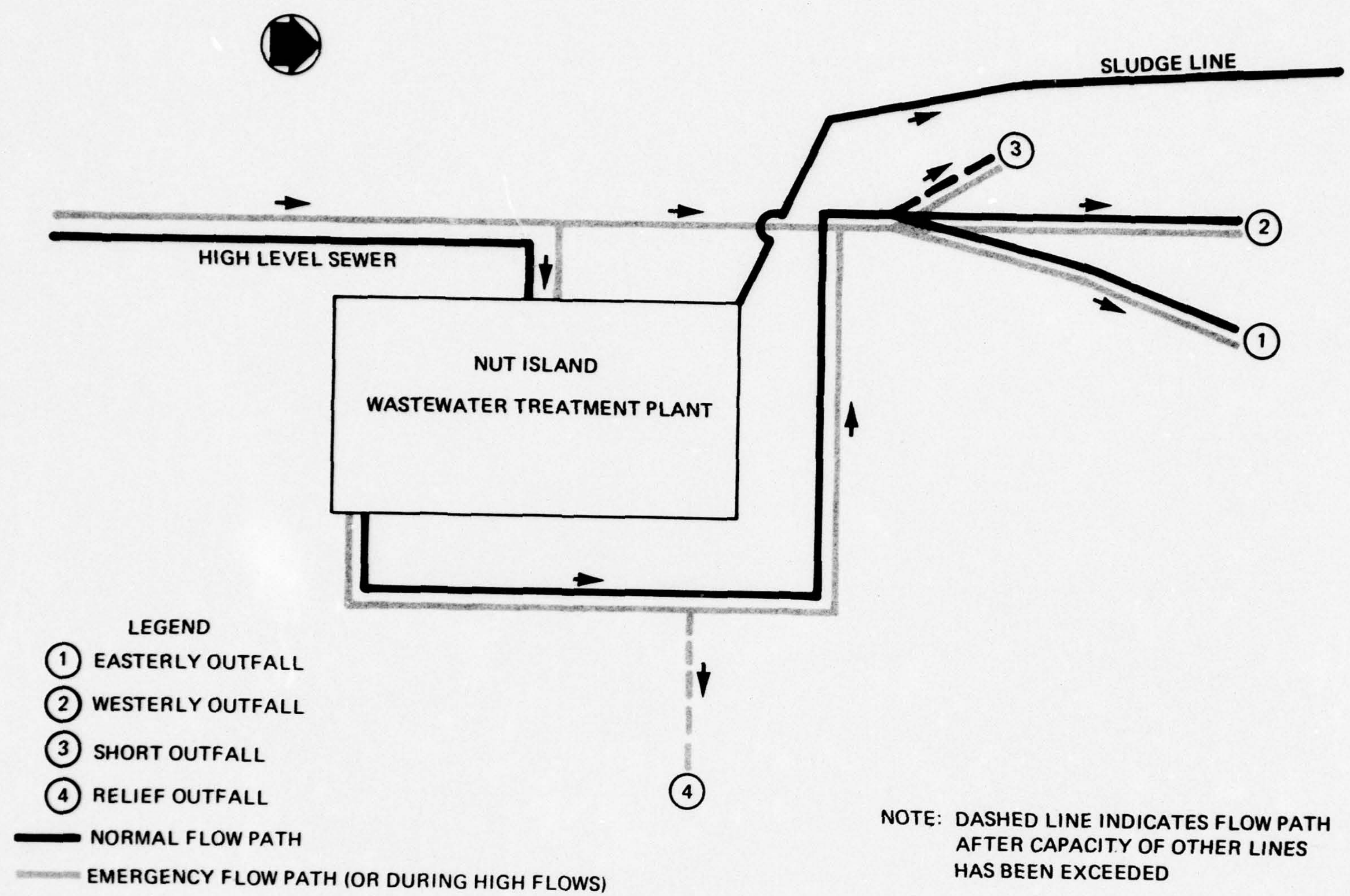


FIG. 2-2 NUT ISLAND WASTEWATER TREATMENT PLANT – OUTFALL SYSTEM

CHAPTER 3

PRIMARY TREATMENT FACILITIES

General

This chapter discusses the need for upgrading the existing preliminary and primary treatment facilities and providing additional facilities at the Nut Island Wastewater Treatment Plant. Most of the existing facilities could be used in an upgrading situation, but certain components of the existing plant, mainly the primary tanks, would require extensive work before they could be used to fulfill not only their intended function of handling flows approximately equal to those received at present, but also meeting higher effluent standards.

Basic Design Criteria

The basic design criteria developed for expansion of the existing primary plant are presented in Table 3-1.

The flows have been developed in accordance with Technical Data Vol. 2. The flows allow for major and minor industrial, commercial and residential wastewater flows and include an allowance for infiltration. Major industrial flows were determined by survey. Peak-day flows have been estimated by applying appropriate factors to dry-weather flows. Peak-day flows include an allowance for peak-wet weather rates of infiltration.

A peak flow of 310 mgd used for design represents the full flow capacity of the incoming Nut Island Trunk sewer. Historically, this rate of inflow has been realized and can be attributed to the quantity of infiltration and inflow that occurs during wet-weather periods. An infiltration/inflow analysis is necessary to finalize the design peak flow. Results of such analysis should be used to adjust peak flows given in Table 3-1 prior to final design.

Present 5-day biochemical oxygen demand (BOD_5) and suspended solids (SS) loads were determined by computer analysis of existing plant data covering the period from January 1970 to December 1972, inclusive. This analysis established the yearly average and peak one-day loads for both BOD_5 and SS.

The analysis indicates that influent SS loads reached magnitudes of 713,000, 527,000 and 439,000 pounds per day on three individual days. Loads of 713,000 and 527,000

TABLE 3-1. BASIC DESIGN CRITERIA
NUT ISLAND PRIMARY EXPANSION

	Present	2000 design	2050
Flow, mgd			
Average day	127	130	150
Peak day	211	224	251
Peak	310	310	310
BOD_5, lb/day			
Average	149,000	201,000	221,000
Peak	363,000	490,000	538,000
SS, lb/day			
Average	222,000	281,000	
Peak	439,000	556,000	
Grit chambers			
Number of units	6	6	
Unit length, ft	80	80	
Unit width, ft	10.4	10.4	
Unit depth, ft	15	15	
Overflow rate, gpd/sq ft			
Average day	25,440	26,042	
Peak day	42,268	44,872	
Peak	62,099	62,099	
Pumping station			
Flow, mgd			
Average day	127	130	
Peak day	211	224	
Peak	310	310	
New aerated grit chambers			
Number of units	-	4	
Unit length, ft	-	74	
Unit width, ft	-	22	
Unit depth, ft	-	15	

TABLE 3-1 (Continued). BASIC DESIGN CRITERIA
NUT ISLAND PRIMARY EXPANSION

	Present	2000 design	2050
Overflow rate, gpd/sq ft			
Average day	-	20,000	
Peak day	-	34,400	
Peak	-	47,600	
Detenton period, min			
Peak	-	3.4	
Preaeration channels			
Number of parallel units	4	4	4
Unit length, ft	166	166	166
Unit width, ft	21	21	21
Number of series units	1	1	1
Unit length, ft	85	85	85
Unit width, ft	12	12	12
Detention time, min			
Average day	17.8	17.4	15.0
Peak day	10.7	10.1	9.0
Primary tanks			
Number of units	6	9	9
6 @ 185' x 64'			
3 @ 215' x 55'			
Overflow rate, gpd/sq ft			
Average day	1,788	1,220	1,410
Peak day	2,970	2,100	2,350
Peak	4,364	2,910	2,910

TABLE 3-1 (Continued). BASIC DESIGN CRITERIA
NUT ISLAND PRIMARY EXPANSION

	Present	2000 design	2050
Chlorine contact			
Detention period, min approximately(1)			
Outfall and effluent conduit			
Average	37	36	
Peak	15	15	
Effluent pumping station			
Flow, mgd			
Average day	127	130	
Peak	310	310	
Outfall			
Diameter, ft	-	5	
Length, ft	-	5,100	

1. Assumes effluent conduit flows essentially full.

pounds per day were considered to be abnormal since they represent concentrations in the influent of 624 mg/L (milligrams per liter) and 390 mg/L, respectively. For this reason, a peak SS load of 439,000 pounds per day was selected as more representative of actual peak conditions for design purposes.

A present average load of 149,000 pounds of BOD_5 per day and 222,000 pounds of SS per day are equivalent to a daily per capita contribution of 0.24 pounds of BOD_5 and 0.35 pounds of SS. To determine future average BOD_5 and SS quantities, the BOD_5 per capita contribution has been increased to 0.30 pounds per day and the SS per capita contribution to 0.42 pounds per day.

Analysis further established peak one-day loads and the ratio between average and peak loads was thus determined. This ratio was then used to forecast future peak one-day loads.

Preliminary Treatment Facilities

As explained in Chapter 2, there are difficulties in the operation of the preliminary treatment facilities at influent flows in excess of 210 mgd. Since these unit processes would continue to experience peak influent flows in excess of 210 mgd, some modifications or expansion of the existing facilities would be required. Recognizing the large capital investment that has been made in these facilities, various alternatives were studied which would permit them to be fully utilized in an upgrading situation.

Preliminary studies indicate that such an arrangement, as shown diagrammatically on Figure 3-1, could be used to successfully incorporate them in an expanded plant facility. The only other alternative that appears possible would be to construct new units of such a capacity that future influent flows could be evenly divided between the new and existing preliminary treatment facilities. This second alternative would be much more costly, particularly so because it would require an additional pumping facility and fill to accommodate the additional units at the existing site.

In the suggested alternative, the existing bar screens would be removed, new bar screens would be placed in the inlet section of the existing grit chambers, the comminutors would be removed, and aerated grit chambers would be constructed downstream from the main pumping facility.

The relocation of the bar screens would subject them to acceptable momentum forces since the velocities at their new location would be much smaller at peak flows than they now experience.

The removal of the comminutors would eliminate the hydraulic head loss through them, and with other channel modifications would tend to minimize at peak flows the amount of surcharge now being experienced in the system.

In order to capture any grit that would pass through the existing preliminary treatment system, four aerated grit chambers would be constructed downstream of the existing main pumping station. These grit chambers would provide a three-minute detention period at peak flows.

The existing screening and grit incinerator would be retained to serve both the new and existing grit facilities.

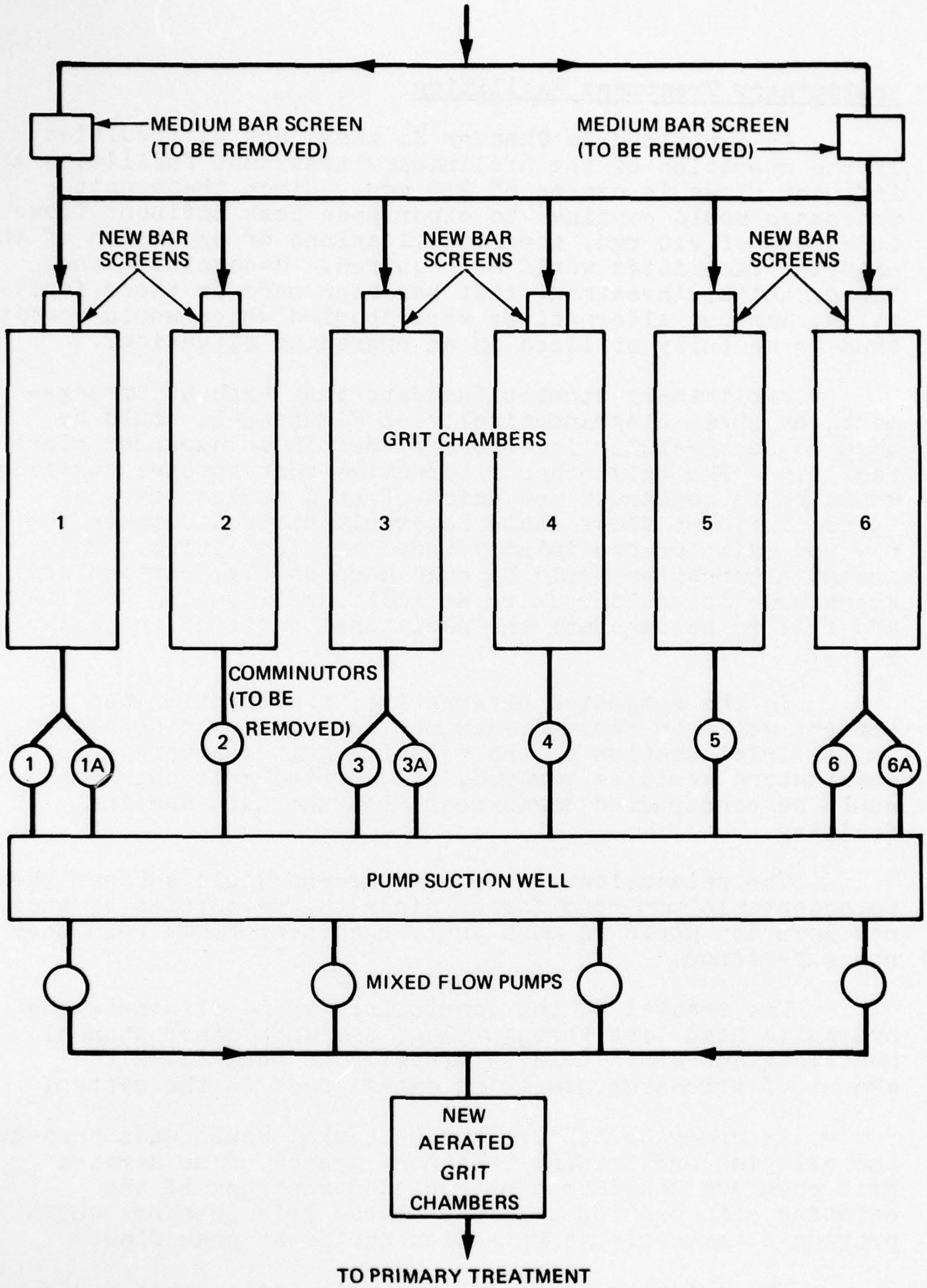


FIG. 3-1 DIAGRAMMATIC LAYOUT REVISED PRELIMINARY TREATMENT FACILITIES – NUT ISLAND WASTEWATER TREATMENT PLANT

With this arrangement, on occasion, the pumps in the main pumping station would be required to pump wastewaters containing grit, rags and some small objects that were capable of passing through the bar screens. Sewage pumps can be designed to handle solid objects as large as 8 inches in diameter, along with grit and rags. This is particularly so in such installations as this, where the discharge head is as low as 10 to 12 feet. For other installations, where pumping stations containing large capacity pumping units when upgraded without provision of preliminary grit, or comminutor facilities, operation has been good without incurring of excessive maintenance costs.

For these reasons, the modifications shown on Figure 3-1 to upgrade the existing preliminary treatment plant have been selected.

Grit Chambers

The six existing grit chambers which are of the rectangular type would remain in service. They would be reequipped as necessary with new chain flights and collectors. The grit would be conveyed pneumatically to the grit hopper and incinerator system as it is now.

The new grit chambers to be added would be of the aerated type with grit collection achieved by means of an overhead clam bucket arrangement. The collected grit would be stored in bins from which the grit would be conveyed to the existing incineration system.

Pumping Station

The existing facility contains four pumping units each rated at 83.5 mgd against a discharge head of 10.3 feet. The combined capacity of these units (334 mgd) would be sufficient to meet the projected peak flow over the design period. However, head requirements may be increased due to the additional downstream hydraulic losses that would be incurred by conveying wastewaters to, through, and away from the new aerated grit chambers. Modifications that would increase the available discharge head can be achieved either by increasing the operating speed of the pumping units or by installing new types of impellers. In any event, if required, new pumping units may be installed. A detailed analysis to determine the most economical selection is beyond the scope of this study, but should be undertaken at the time of design.

Preaeration Tanks

The preaeration tanks consist of four units in parallel and one in series, all equipped with sparger swing-type diffusers. In the upgraded plant, all units would be maintained in service. The swing-type diffusers need replacement and we would recommend that they be replaced where possible with fixed-type diffuser systems. This is because our experience indicates that fixed-type diffuser systems are less costly to maintain.

Primary Tanks

It is recommended that the existing six primary tanks be supplemented by three tanks, all equipped with covers. This will permit the primary facilities to operate at overflow rates (gpd (gallons per day) per square foot) of 2,910 under peak flow conditions. We have increased the number of primary tanks because without doing so, we would anticipate that solids would be washed out of the existing primary tanks at peak flows due to the excessive overflow rates. Overflow rates as given in Table 3-1 are considered satisfactory, provided that secondary treatment follows the primary treatment process.

The three new tanks would have slightly different dimensions than the existing tanks to insure that they could be located within the limits of the existing site. Accordingly, with this modification additional land would not be required.

In the event primary treatment alone is permitted in conjunction with a deep ocean discharge, then two additional primary tanks (five in all) should be added to the system. With this addition, the design overflow rate would be 1,000 under average flow conditions and 2,380 under peak flow conditions. These lower overflow rates should improve the SS removals to that level where deep ocean discharge may be acceptable.

Outfall System

The existing outfall system consists of two long outfalls (5,830 and 5,545 feet), a shorter outfall (1,412 feet), and an emergency overflow weir with a shoreline discharge. The emergency overflow weir should be abandoned since the discharge of primary effluent directly to the shoreline of Nut Island under any conditions would not be acceptable. In addition, the shorter outfall should be

extended by approximately 5,000 feet and provided with diffusers at which point, approximately 30 feet of submergence would be available at mean low water. This extension would permit all three outfalls to be used at all times.

Chlorination Facilities

Pre- and postchlorination is practiced at the Nut Island Treatment Plant. For this purpose, the plant is equipped with four chlorinators, each having a capacity of 8,000 pounds per day. The total capacity of the installation is 32,000 pounds per day.

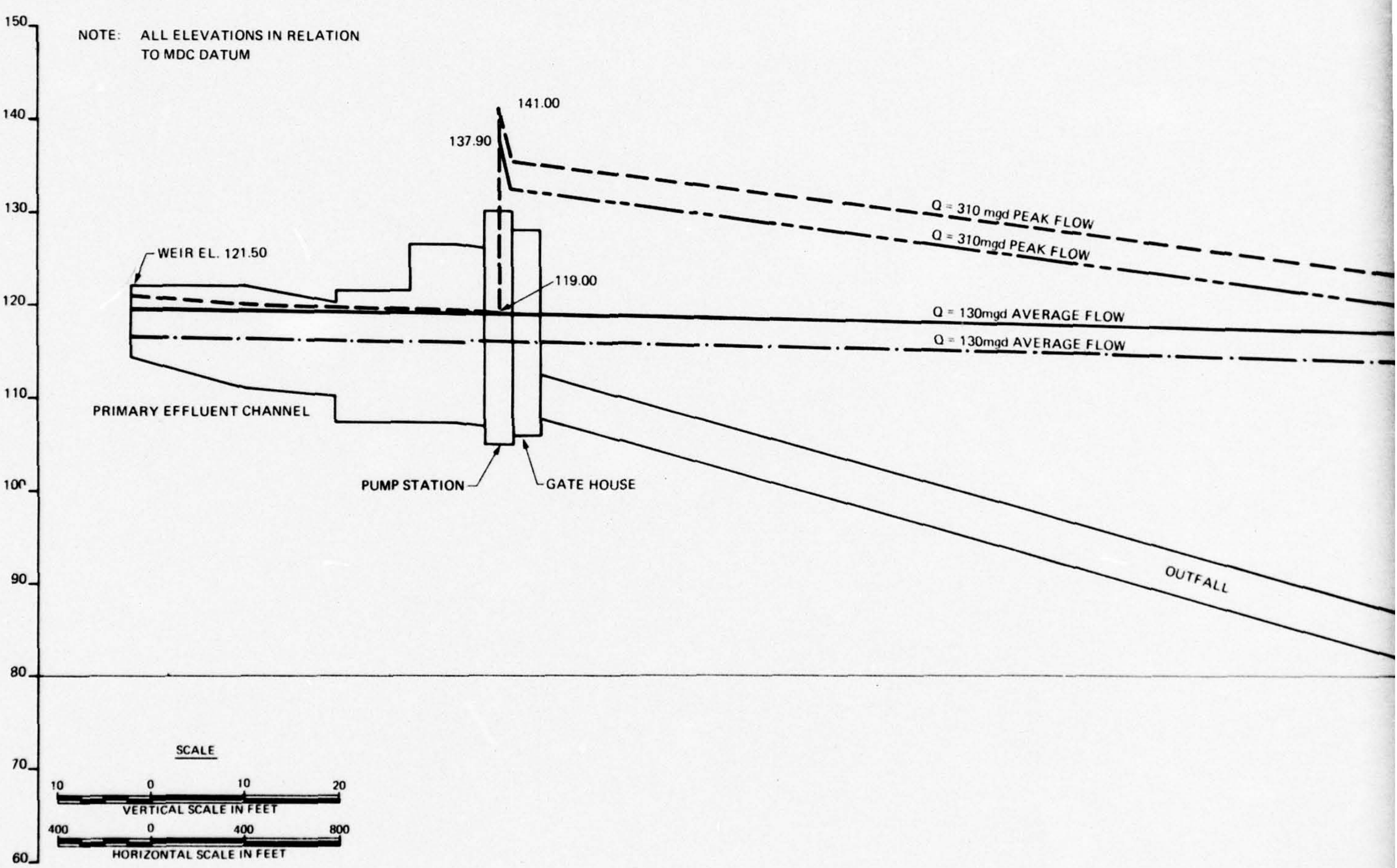
It is recommended that the existing chlorinators and their appurtenant equipment be removed from their present location in the Administrative Building to a new building constructed for this specific purpose. A new chlorine feed system should be provided that would permit receipt of chlorine in tank truck lots.

The actual chlorine dosage that would be required to meet the usual standards of maintaining a 1 mg/L chlorine residual in the effluent for at least 15 minutes must be determined by test. Normally, a chlorination capacity that would provide a dosage of 12 mg/L is sufficient for primary effluents. With a dosage of 12 mg/L and a peak flow of 310 mgd, the daily capacity requirements would be 31,000 pounds which is within the capacity of the existing system, without providing for prechlorination and standby equipment. However, the capacity of the existing chlorination systems should be increased to provide for prechlorination of the incoming wastewaters and for standby facilities.

With three long outfalls in service, the outfall system in conjunction with the existing effluent conduits would provide a 15-minute retention period.

Effluent Pumping Station

Preliminary studies indicate that an effluent pumping station may be needed. A preliminary hydraulic profile for the primary treatment plant from the primary effluent weirs to the end of the outfalls (three in service) is shown on Figure 3-2. The profile indicates that at maximum tide of record El 115.7 (MDC Datum) and peak flow 310 mgd, gravity discharge from the primary tanks to the sea would not be possible. It is estimated that approximately 1 percent of the time it would be necessary to operate this pumping facility to discharge treated effluent.



NOTE: ALL ELEVATIONS IN RELATION TO MDC DATUM
150
140
130
120
110
100
90
80
70
60
141.00
137.90
119.00
WEIR EL. 121.50
Q = 310 mgd PEAK FLOW
Q = 310mgd PEAK FLOW
Q = 130mgd AVERAGE FLOW
Q = 130mgd AVERAGE FLOW
PRIMARY EFFLUENT CHANNEL
PUMP STATION
GATE HOUSE
OUTFALL
SCALE
10 0 10 20
VERTICAL SCALE IN FEET
400 0 400 800
HORIZONTAL SCALE IN FEET

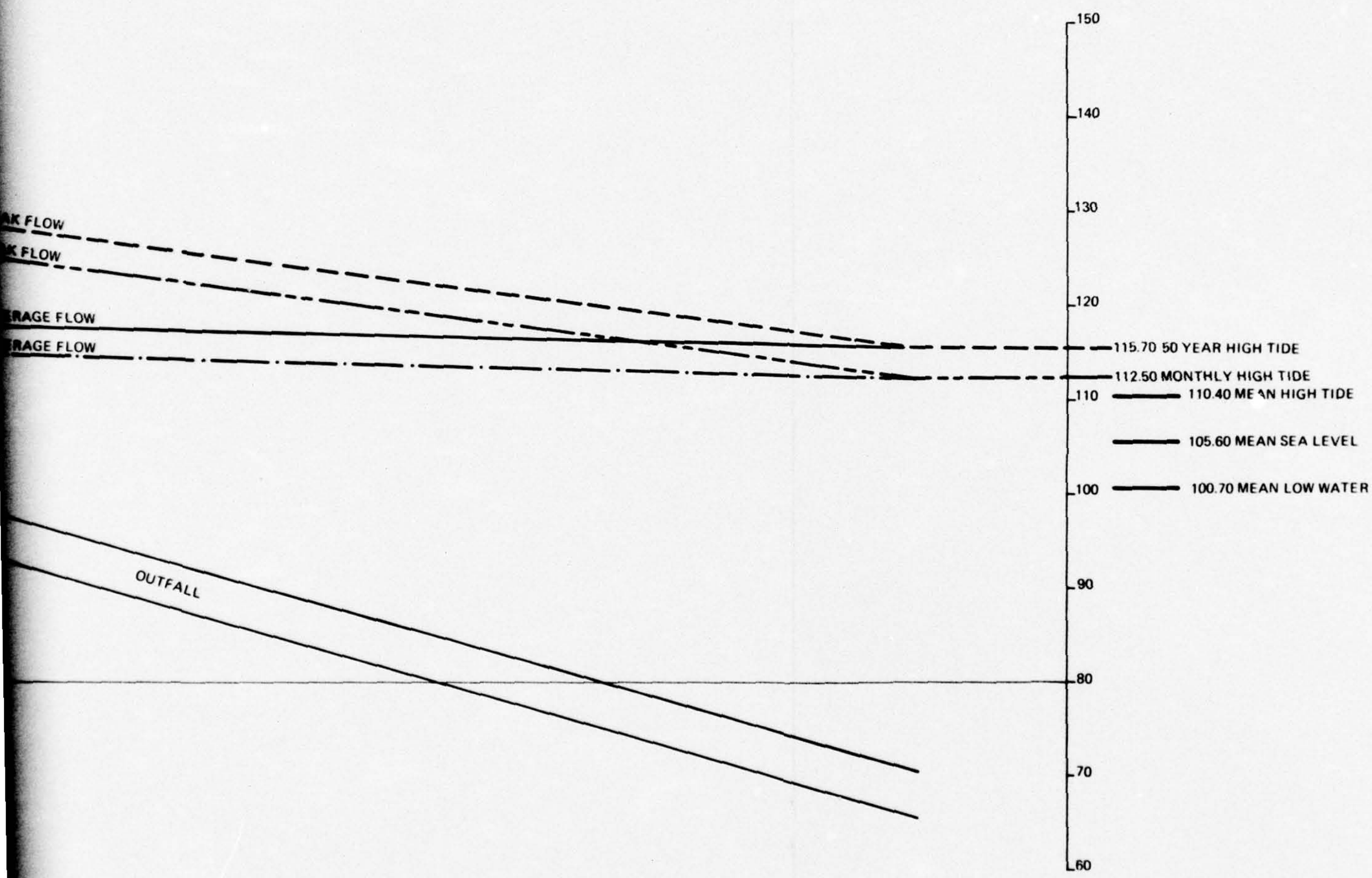


FIG. 3-2 NUT ISLAND WASTEWATER TREATMENT PLANT PRELIMINARY HYDRAULIC PROFILE PRIMARY EXPANSION

2

The hydraulic profile shown on Figure 3-2 assumes that the elevation of the effluent weirs in the primary tanks can be established at El 121.50 (MDC Datum). These weirs were originally constructed at El 122.50, but in some cases, the tanks have settled by as much as 2 feet. The hydraulic profile also assumes that three outfalls will be in service. The original outlet gate house was constructed so that it would be possible to provide five independent outfalls. Preliminary calculations indicate that even if all five outfalls were constructed, it would be necessary to raise the primary tank effluent weirs to an elevation exceeding 124 feet (MDC Datum) to avoid the necessity of providing an effluent pumping station. Since a preliminary evaluation of the structural stability of the primary tanks precludes raising them, an effluent pumping station would be required. During detailed facilities planning, the need for an effluent pumping station should be evaluated further and discussed with officials from EPA and other regulatory agencies. However, in any event, with the construction of secondary treatment facilities, an effluent pumping station would be required.

The station would be equipped initially with five pumping units each capable of pumping 78 mgd against a head of approximately 22 feet. This would provide an available capacity of 310 mgd with the largest pumping unit out of service.

Scum Incinerator Building

Current sludge management planning, as recommended for both the Deer and Nut Island treatment plants* indicates that sludge removed by the primary process would be thickened at the Nut Island site. The thickened sludge would then be pumped through dual force mains to Deer Island for further processing. To reduce the level of maintenance required to keep the transfer force mains in service, scum would not be included in the transfer processes. This is because scum contains a larger percentage of grease which could quickly plug the transfer force mains through grease buildup. Therefore, any scum collected in the treatment process would be disposed of on the site. Such disposal should be by incineration. Scum has been successfully incinerated at many installations including the Nut Island Treatment Plant.

*Havens and Emerson Consulting Engineers, A Plan for Sludge Management, prepared for the Commonwealth of Massachusetts, Metropolitan District Commission, August 1973.

There are several incineration systems that have been developed for the disposal of scum. At the time of design, these various systems should be evaluated as to their applicability for use at this site.

CHAPTER 4

SECONDARY TREATMENT

General

Secondary treatment would be required in accordance with Technical Data Vol. 2. As in the case of the Deer Island Treatment Plant, the activated-sludge process was primarily selected to achieve secondary treatment. This selection is based to some degree on the advantages that would accrue to the Metropolitan District Commission in such things as training of personnel, limiting of inventories, and in maximizing sludge management efficiencies if both plants are of similar design. However, detailed planning including an investigation of alternative treatment process is required to establish the final process to be used.

The unit processes that constitute an activated-sludge process consist of aeration and final tanks. These unit processes are discussed in the following paragraphs. This chapter will also consider the effect that this expansion would have, if any, on the primary process units described in Chapter 3.

Sizing of Facilities

Various activated-sludge modifications have been developed, most of which can produce an equivalent quality of effluents. In sizing the aeration tanks, the step aeration process was selected as applicable in this situation. This process permits the installation of smaller aeration tanks than the conventional activated-sludge process. It also has the advantage that a great deal of operational flexibility is readily available. The process is designed to maintain 2,000 to 3,000 mg/L of MLSS (mixed liquor suspended solids) within the aeration systems and to accept a BOD_5 (load) to MLSS ratio varying from 0.25 to 0.40. With these design parameters, the system would reduce the BOD_5 by 85 percent or better, including primary removals, and would produce approximately 0.6 of a pound of excess sludge per pound of BOD_5 removed.

Since the aeration tanks would be placed on fill, it is important that the aeration tanks be kept as small as possible. There is an activated-sludge process available that utilizes pure oxygen rather than air as a source of oxygen supply. This system can be designed with aeration

units smaller than those required in the step aeration process. However, such a system should be piloted to determine acceptable design parameters, preferably at a large scale before it is considered for design. Comparative pilot-plant testing is deemed desirable to determine maximum organic loading rates, settling tank overflow rates and solids loading rates, oxygen requirements and sludge generation factors. Since such work is beyond the scope of this study, we have not selected this process. We recommend that the use of the pure oxygen system be investigated before the final selection is made of the process to be designed. This is particularly important at this site because of the smaller fill requirements.

The cost saving available from the use of the smaller oxygen aeration tankage is at least partially offset by the crosswalls required for staged reactors, the gastight covers, and expensive cyrogenic oxygen generating systems. Due to the higher MLSS concentration used with oxygen systems, the final settling tanks may have to be made larger to avoid solids loading problems. In addition, consideration must be given to relative operating and maintenance cost of more complicated oxygen generator and numerous mechanical aerators compared to blower systems.

Similar cost analysis should be carried out to establish the optimum depth for standard aeration tanks as compared to the cost of energy requirements.

Basic Design Criteria

The basic design criteria relative to the secondary extension of the Nut Island Treatment Plant are presented in Table 4-1. The average and peak BOD_5 loads on the secondary treatment process are set forth in Table 4-1. These loads have been established as previously described under the subheading Basic Design Criteria in Chapter 3, and allow for a 30 percent removal in the primary process and recycled loads.

Aeration Tanks

Twelve aeration tanks, each 80 feet wide and 224 feet long and 15 feet deep, would be required to handle the projected BOD_5 loads under design conditions. Each tank would be so arranged that it would have four passes. Proper channeling would be provided so that the effluent from the primary system may be added at the head end of

each pass. This flexibility in applying wastewater to the aeration tanks can be extremely advantageous in controlling the operational process.

TABLE 4-1. BASIC DESIGN CRITERIA
SECONDARY EXTENSION - NUT ISLAND

	Present	2000 design	2050
Flow, mgd			
Average day		130	150
Peak day		224	251
Peak		310	310
Aeration tanks			
BOD_5, lb/day(1)			
Average day		160,800	176,800
Peak day		392,000	430,000
Number of units		12	14
Unit length, ft		224	224
Unit width, ft		80	80
Unit depth, ft		15	15
Loading, lb of BOD_5/ 1,000 cf			
Average		50	47
Peak		121	114
Final tanks			
Number of units		16	16
Type		Circular	Circular
Diameter, ft		145	145
Depth, ft		15	15
Overflow rate, gpd/sq ft			
Average day		490	570
Peak		1,170	1,170

1. Includes recycle load.

Final Tanks

Sixteen circular tanks, each having a diameter of 145 feet, would be provided. Each tank would be equipped with a sludge and scum removal mechanism. According to the present sludge management planning, the waste-activated sludge would be thickened through the use of flotation thickeners. The thickened sludge would be pumped to Deer Island for further processing. Four return and waste-activated sludge pumping stations are provided since preliminary planning indicates that the sludge piping arrangement between final and aeration tanks can be minimized.

While shorter sludge detention times are desirable and achievable with circular units, limited space available may dictate use of rectangular tanks in final design.

Chlorination Facilities

Since the peak flow through the plant would not increase with the addition of secondary treatment, there will be no need to increase the capacity of the chlorination installation.

Based on preliminary layouts, 15 minutes retention time should be available in the effluent conduit and outfall system. For this reason, chlorine contact basins have not been provided. However, in plant layouts, space has been provided for them along with a cost allowance in the event they are required by the regulatory authorities.

Effluent Pump Station

With expansion of the plant from primary to secondary treatment, the capacity of this facility need not be increased since the peak flow would be the same as that established for the primary plant. Due to the additional hydraulic losses within the secondary system, we estimate that the pumps would be required to discharge against a maximum head of approximately 29 feet. The pumping facility should be required to operate approximately 34 percent of the time, provided that three outfalls are available for service.

CHAPTER 5

ALTERNATIVE ARRANGEMENTS

General

Nut Island was originally a four-acre island that has been filled commencing in 1893 to its present 17-acre size. The Island is totally occupied by the primary treatment plant and has no major topographic features, is leveled and the shore is surrounded by a steep riprap wall.

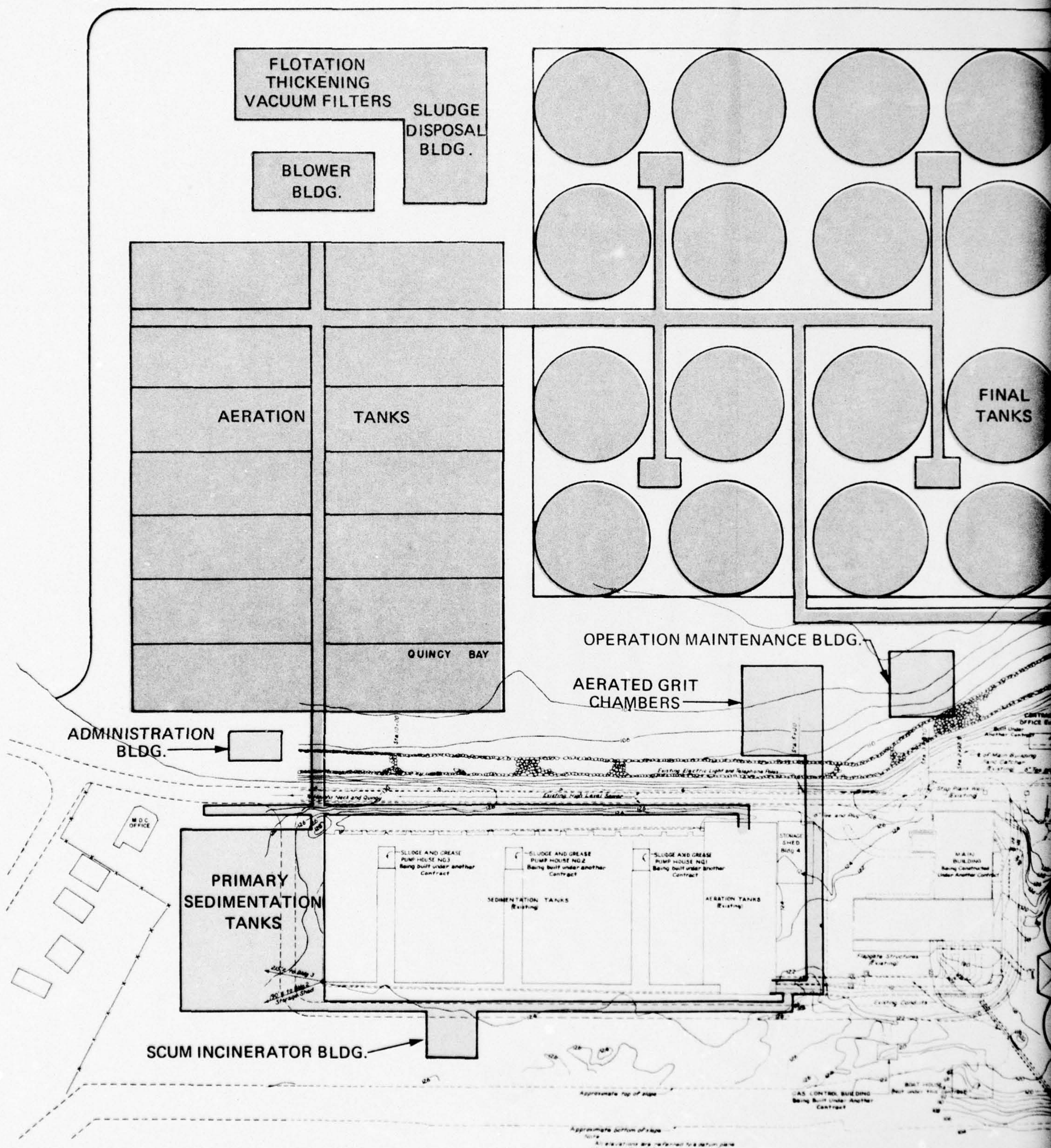
The Boston Harbor Island Comprehensive Plan recognizes the use of the Island for wastewater treatment purposes. The plan does propose the development of a fishing pier and some landscaping, mainly the planting of trees, to improve the appearance of the Island.

Alternative Arrangements

Although the Nut Island site is limited in developable area, the three additional primary tanks that would be required in conjunction with secondary treatment as shown in Table 3-1 can be provided without additional filling. However, the filling of 3.3 acres would be required initially to allow for the construction of an operations building, aerated grit chambers and a new administration building.

The major problem in developing the site is providing sufficient area for the secondary treatment process. To accommodate the aeration tanks, blower building, final tanks and a sludge processing building would require some additional 24.8 acres of fill as shown on Figure 5-1.

In light of the recognition of the extent of this fill, two additional layouts were prepared for the Nut Island expansion. These alternatives were developed with the express idea of minimizing the extent of the fill into the Harbor on the west side of the Island. A northerly extension of the Island, as shown on Figure 5-2, would reduce this, but would also tend to reduce the channel between Nut Island and Peddocks Island. However, local sailing enthusiasts indicate that this particular channel is difficult to navigate due to currents and that any plans for filling should consider this at riptides. Splitting of the fill area between the eastern and western shorelines is shown as an alternative on Figure 5-3. Boring investigations undertaken for the settlement analysis of the


FLOTATION
THICKENING
VACUUM FILTERS
SLUDGE
DISPOSAL
BLDG.
BLOWER
BLDG.
AERATION
TANKS
FINAL
TANKS
QUINCY BAY
OPERATION MAINTENANCE BLDG.
AERATED GRIT
CHAMBERS
ADMINISTRATION
BLDG.
PRIMARY
SEDIMENTATION
TANKS
SCUM INCINERATOR BLDG.
SEDIMENTATION TANKS
Existing
AERATION TANKS
Existing

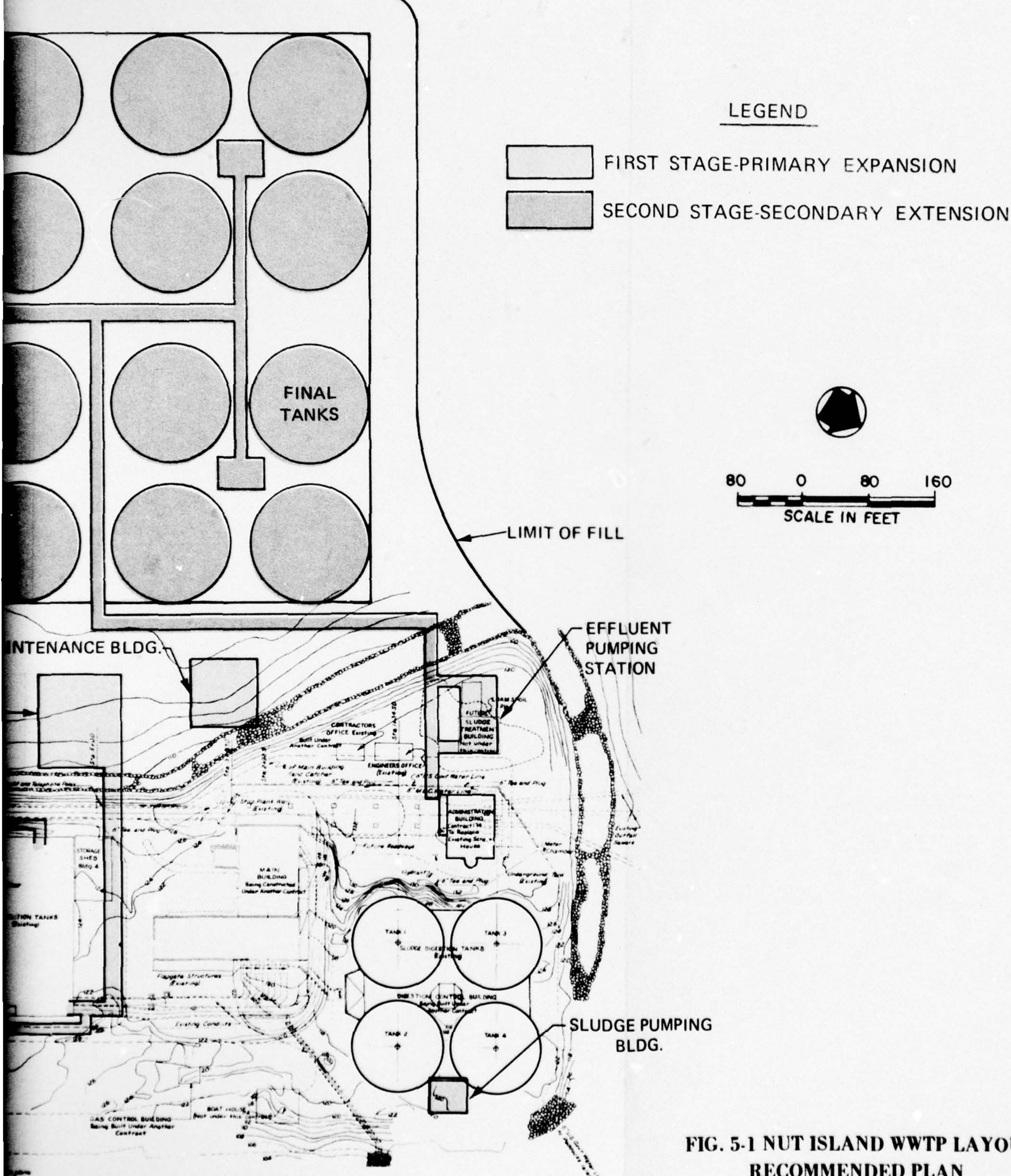


FIG. 5-1 NUT ISLAND WWTP LAYOUT-RECOMMENDED PLAN

2

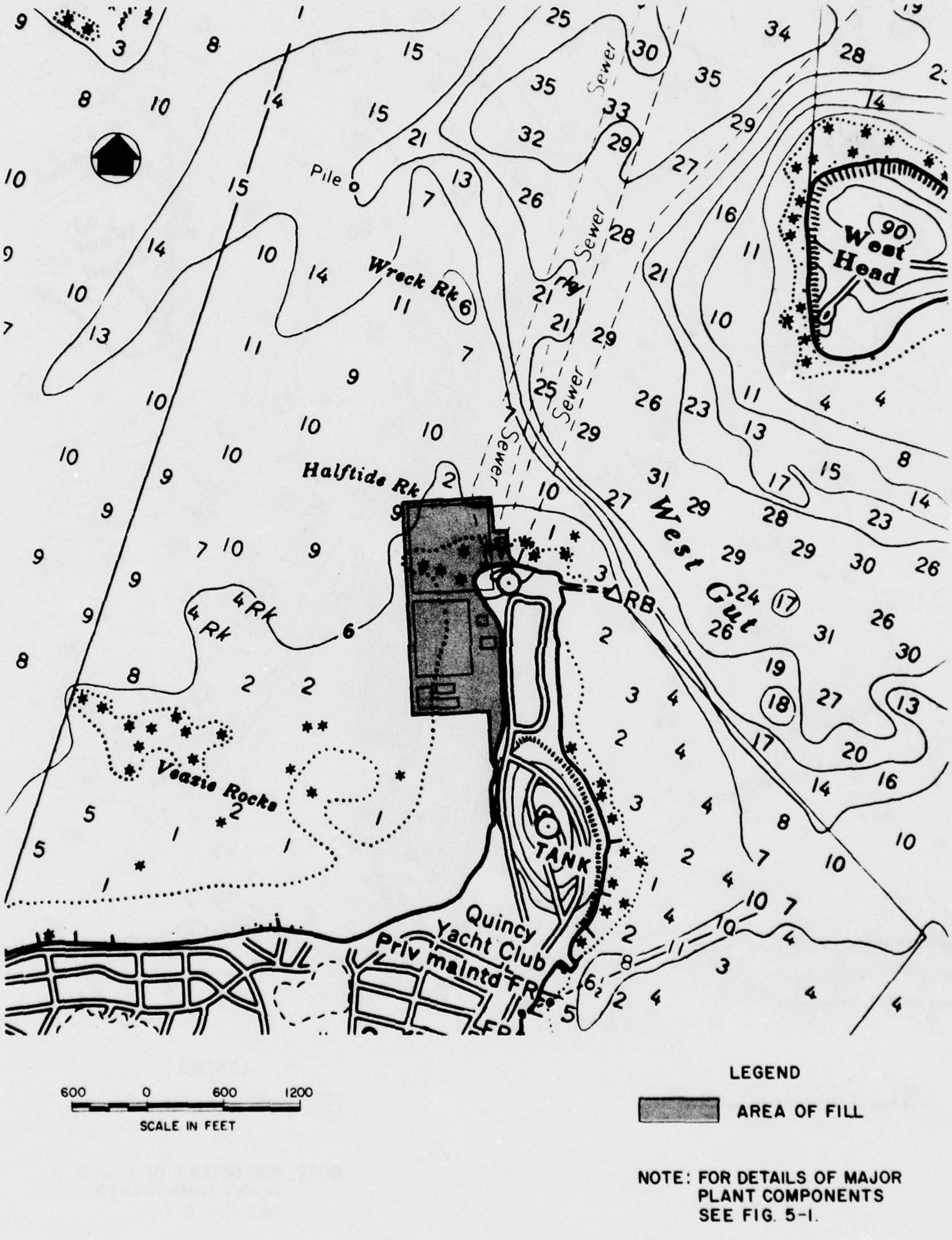
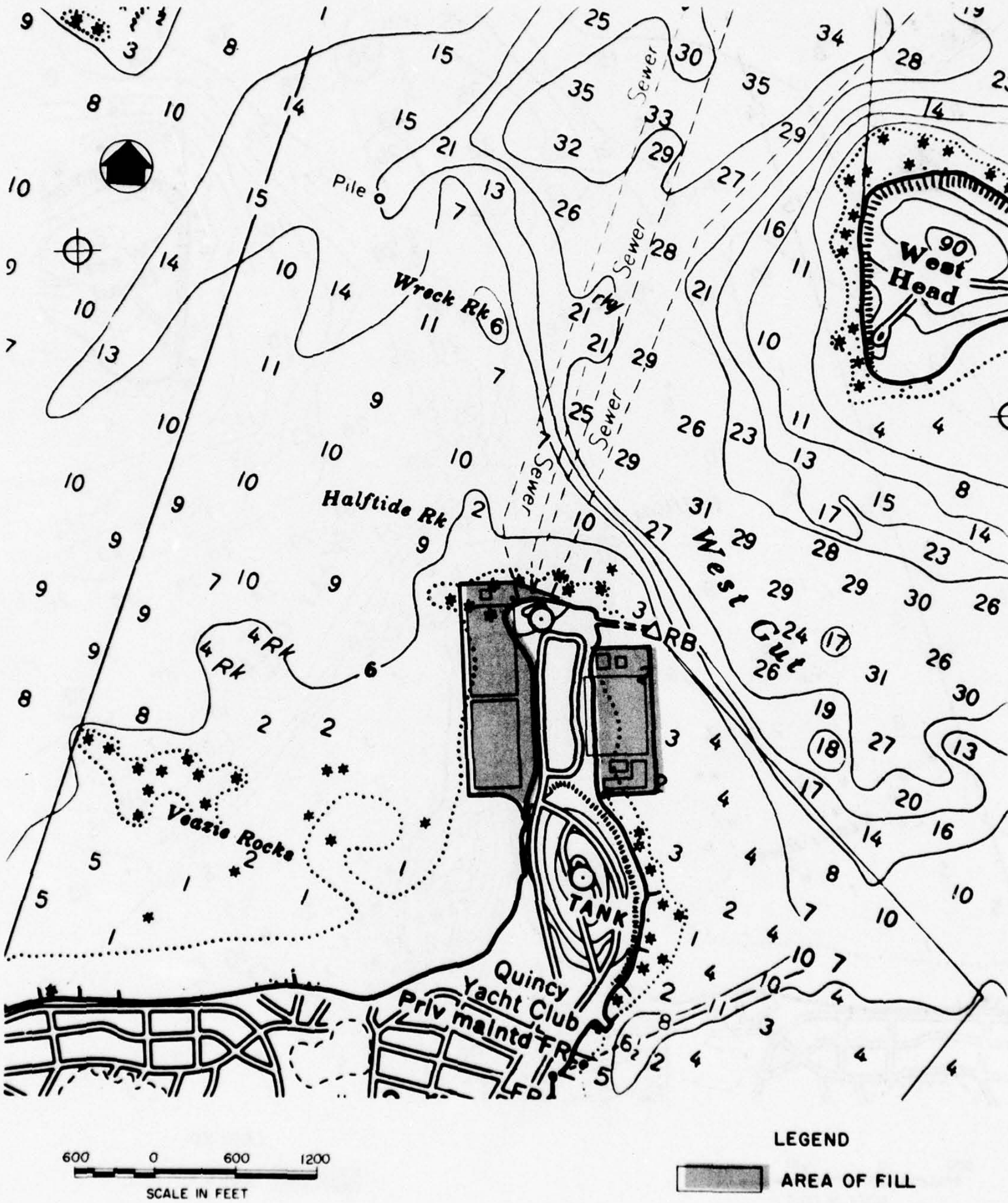


FIG. 5-2
NUT ISLAND WWTP-ALTERNATIVE LAYOUT-NORTHERLY EXTENSION



LEGEND

AREA OF FILL

NOTE: FOR DETAILS OF MAJOR PLANT COMPONENTS SEE FIG. 5-1.

**FIG. 5-3 NUT ISLAND WWTP-
ALTERNATIVE LAYOUT-EASTERLY AND WESTERLY EXTENSIONS**

existing primary tanks imply that development of the easterly side of the Island might cause further settlement of the existing structures. Therefore, detailed studies related to filling at Nut Island will have to consider their engineering problems along with the aesthetic and environmental effects.

In addition to these various site layouts relating to the location of facilities needed for secondary extension at Nut Island, several additional alternatives utilizing remote locations, in total or in part, were also investigated. These alternatives were as follows:

1. Locate primary facilities on Nut Island, secondary facilities on Long Island.

2. Locate primary facilities on Nut Island, secondary facilities on Peddocks Island.

3. Locate entire plant inland at Broad Meadows in Quincy.

There is sufficient area on Long Island in the vicinity of Bass Point to provide for the Nut Island secondary treatment facilities. The Boston Harbor Plan calls for the development of this area for recreational purposes. The use of this site would require that primary effluent be conveyed to Long Island for secondary treatment and that new outfall pipelines be made available for this site making the construction cost of this alternative about $25 million greater than expansion at Nut Island. In addition, operation costs would increase due to split operation, sludge handling and administration, and due to additional pumping. For these reasons, this alternative was not recommended.

The southern part of Peddocks Island would provide sufficient area with some excavation and a minor quantity of fill to accommodate the Nut Island secondary facilities. The Boston Harbor Island Comprehensive Plan calls for the development of the southern portion of the Island through the construction of campsites and trails for recreational purposes, although the Boston Harbor Island Comprehensive Plan does indicate that ferry access would be made available to this Island.

Since day-to-day operation of the secondary plant would require roadway access, it would be necessary to construct a bridge or causeway to this Island. Providing such a causeway, the necessary submerged piping from Nut Island to Peddocks Island and a new outfall system would

be prohibitively expensive. For this reason and due to expected operational problems resulting from split facilities, this alternative was not recommended.

Broad Meadows is located in Quincy along the Neponset River, some 2.5 miles west of the existing Nut Island Treatment Plant and near to the High Level Sewer. A portion of the meadows was formerly used as a U. S. Naval Reservation and it is this portion of the meadows that the plant would occupy. Part of the meadows is submerged at extremely high tides and would require filling before it could be used as a plant site. However, present planning has reserved part of the area for the development of a local community college.

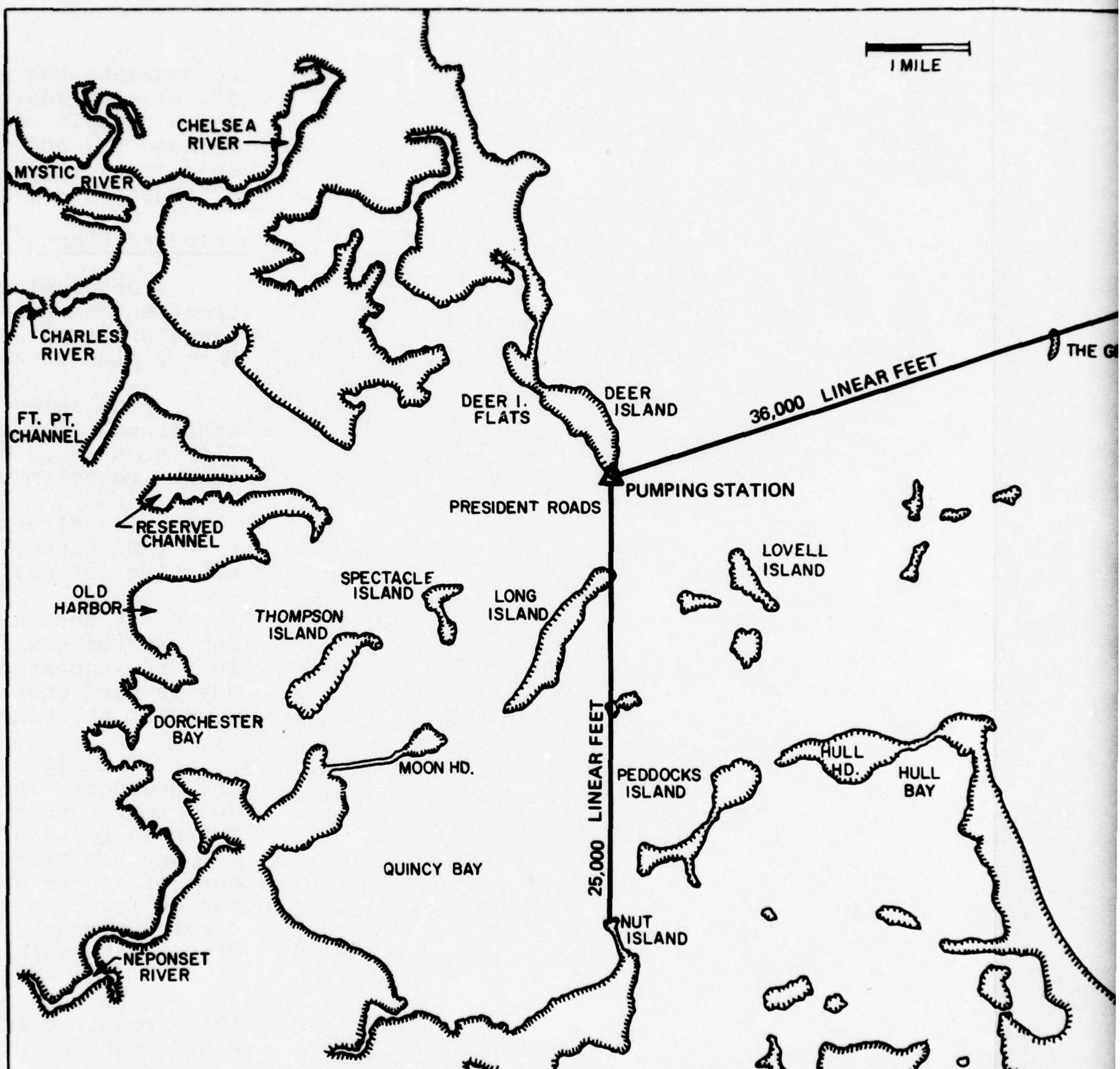
The estimated cost of this plan, some $139 million, would approximate the cost of upgrading facilities and extending to secondary treatment at Nut Island. Of this amount, approximately $17.5 million would be required for site development which is somewhat but not substantially less than the $23.5 million required for site development at Nut Island.

Building a plant at this location would permit use of the existing High Level Sewer for treated wastewater discharge to the present outfall system. The present site on Nut Island could be converted to recreational use. It is, therefore, recommended that further consideration be given to this alternative, should land in that area become available.

Other alternatives considered consisted of providing primary treatment in conjunction with ocean discharge and providing advanced wastewater treatment facilities at the Nut Island site.

An arrangement that would permit ocean discharge is indicated on Figure 5-4. Primary effluent would be conveyed by gravity to Deer Island where the combined wastewaters effluent of Deer and Nut Island would be pumped to the ocean through approximately 36,000 feet of deep tunnel. As indicated in the Deer Island Wastewater Treatment Plant report, this alternative is cost-effective. However, this alternative does not meet the statutory requirements that secondary treatment must be provided to all ocean wastewater discharges. For this reason, this alternative was not considered any further.

Advanced wastewater treatment facilities at Nut Island would require an additional fill of 14 acres to



I MILE
CHELSEA RIVER
MYSTIC RIVER
CHARLES RIVER
FT. PT. CHANNEL
RESERVED CHANNEL
OLD HARBOR
DEER I. FLATS
DEER ISLAND
36,000 LINEAR FEET
THE G
PUMPING STATION
PRESIDENT ROADS
LOVELL ISLAND
SPECTACLE ISLAND
LONG ISLAND
THOMPSON ISLAND
DORCHESTER BAY
MOON HD.
25,000 LINEAR FEET
PEDDOCKS ISLAND
HULL HD.
HULL BAY
QUINCY BAY
NUT ISLAND
NEPONSET RIVER
WEYMOUTH BACK RIVER
WEYMOUTH FORE RIVER

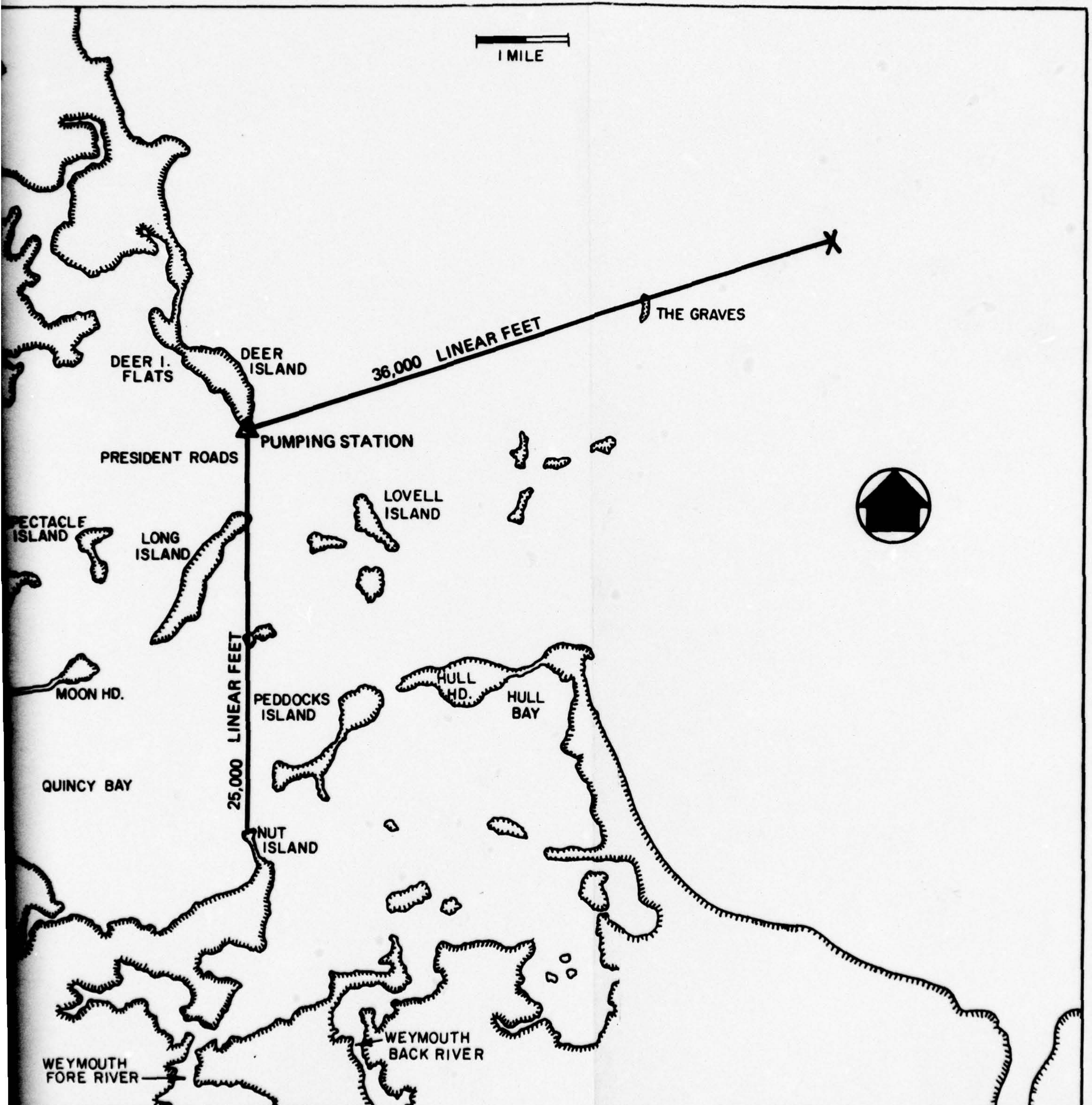


FIG. 5-4

OCEAN OUTFALL DISCHARGE PLAN

accommodate the necessary facilities. It is estimated that $82 million would be needed to provide advanced treatment units capable of handling an average daily flow of 130 mgd. Because any additional fill over that already required would be objectionable and because of the additional cost, this alternative was not given any further consideration.

Selected Plan

Developing Nut Island further for adequate wastewater treatment purposes was selected and detailed out for purposes of developing construction and operation cost budgets. Such a plan is shown on Figure 5-1.

The selected plan would require approximately an additional 24.8 acres of fill for secondary treatment. The fill area would be limited to the west side of the Island in the recommended alternative.

The site would be developed to an elevation of 126 feet (MDC Datum) which is the approximate level of the existing island.

It should be noted that it may be possible to support the new facilities on a concrete slab which is in turn supported on piles. Whether or not this approach may be more economical than placing fill should be determined at the time of design.

The site as developed is large enough to accommodate the necessary facilities, including a sludge disposal building. Under present sludge management planning, it is intended to pump thickened sludge from Nut to Deer Island for further processing. Except for the site costs, the cost of sludge processing is excluded from this report, but may be found in another study.* In the event this plan is carried through, then there would be no need for a sludge disposal building at this site.

The estimated cost for providing all of the facilities required for secondary treatment, excluding any sludge management facilities, is given in Table 5-1.

*Havens and Emerson Consulting Engineers, A Plan for Sludge Management, prepared for the Commonwealth of Massachusetts, Metropolitan District Commission, August 1973.

TABLE 5-1. CONSTRUCTION COST - NUT ISLAND WASTEWATER TREATMENT PLANT[1]

Item	Cost
Site development	$ 23,516,000
Primary tanks[2]	2,593,000
Aerated grit chambers	4,683,000
Aeration tanks	15,080,000
Final tanks	12,478,000
Conduits-galleries	9,593,000
Chlorine contact tanks	2,539,000
Chlorine equipment and housing	487,000
Scum incinerator	587,000
Effluent pump station	4,196,000
R.S. and W.A.S. pump station	3,907,000
Revamp existing primary and influent pump station	13,485,000
Operations building	3,686,000
Administration building	1,431,000
Blower building	10,017,000
Outside piping and landscaping	10,821,000
Electrical and instrumentation	13,101,000
Plant Cost	$132,200,000
Outfall Cost	5,036,000
Total	$137,236,000

1. Additional costs for sludge management are presented in A Plan for Sludge Management for the Metropolitan District Commission, Havens and Emerson Limited, August 1973, available at the Metropolitan District Commission.
2. Additional cost for covers $4,132,000.

The estimated cost is based on an ENR (Engineering News-Record) Index of 2200 and includes a 35 percent allowance for engineering and contingencies. The cost does not provide for flotation thickeners, sludge disposal facilities or other appurtenant sludge management equipment. The estimated cost does not include legal fees or interest during construction.

CHAPTER 6

PHASED DEVELOPMENT

General

A phased development of the Nut Island Treatment Plant is discussed in this chapter. The phased development presented is in accordance with the priorities for improvements, additions or extensions to the Metropolitan District Commission sewerage systems that have been established.

Phased Development

The existing Nut Island Treatment Plant provides primary treatment and was designed for an average daily and peak flow of 112 and 300 mgd, respectively. As indicated in Table 3-1, these flows are slightly smaller than the corresponding design projected flows of 130 and 310 mgd. It would appear then that, with minor modifications, the plant could be revamped to meet primary design requirements. For several reasons, however, this is not the case. The existing primary tanks have settled, rendering them ineffective with relationship to scum removal and inefficient with regard to solids removal. Since the time these primary tanks were designed, design parameters have been upgraded to meet higher effluent standards. These upgraded design parameters, as indicated in Chapter 2, would require the construction of three additional primary tanks. Furthermore, there are some operational difficulties within the preliminary treatment system.

The first priority should be to revamp and provide such new facilities that would permit the existing primary treatment plant to operate efficiently and effectively when handling the design flows.

The second-phase development would consist of providing those facilities that would permit secondary treatment.

The construction costs given in this chapter are based on an ENR Index of 2200 and include a 35 percent allowance for engineering and contingencies. Costs do not include the cost of legal fees or financing during construction.

First-Phase Construction Costs

Under the first-phase development, the work would consist essentially of revamping the existing primary tanks and the influent pumping station, providing aerated grit chambers, an effluent pumping station, an operations building, upgrading the existing chlorination facility, and extending the short outfall conduit. The cost of doing this work is presented in Table 6-1.

TABLE 6-1. FIRST-PHASE CONSTRUCTION COST

Item	Cost
Site development	$ 3,559,000
Primary tanks[1]	2,593,000[1]
Aerated grit chambers	4,683,000
Operations building	2,304,000
Effluent pump station	4,196,000
Chlorine contact tanks	2,539,000
Conduits-galleries	2,859,000
Chlorination equipment and housing	487,000
Scum incinerator	587,000
Revamp existing primaries and influent pump station	13,485,000
Outside piping and landscaping	3,696,000
Electrical and instrumentation	4,512,000
Plant Cost	$45,500,000
Outfall Cost	5,036,000
Total	$50,536,000

1. Additional cost for covers $4,132,000.

Second-Phase Construction Costs

The work that is discussed in Chapter 4 consists mainly of the construction of those facilities that would be required to provide secondary treatment. In addition to the facilities already described in Chapter 4, a new administrative building would be provided and the operation building extended to meet the requirements of a secondary plant. The estimated cost of providing all these facilities is set forth in Table 6-2.

TABLE 6-2. SECOND-PHASE CONSTRUCTION COST

Item	Cost
Site preparation	$19,957,000
Aeration tanks	15,080,000
Final tanks	12,478,000
Conduits-galleries	6,734,000
Administration building	1,431,000
Blower building	10,017,000
Sludge pump stations(1)	3,907,000
Operations building	1,382,000
Outside piping and landscaping	7,125,000
Electrical and instrumentation	8,589,000
Total	$86,700,000

1. Return sludge and waste-activated sludge.

Operation and Maintenance Cost

The annual operating and maintenance costs that would be incurred during the first phase and second phase operational period are presented in Table 6-3. During the first phase of operation, it is assumed that all power requirements would be supplied from the plant's internal electrical generation system.

TABLE 6-3. ANNUAL OPERATING AND MAINTENANCE COST

First Phase		
Manpower (93)		
	Operation and maintenance	$1,204,000
Chemical		
	Chlorine	486,000
Maintenance		
	Plant	337,000
	Total	$2,027,000
Second Phase		
Manpower (112)		
	Operation and maintenance	$1,451,000
Fuel and electrical power		
	Fuel	100,000
	Electrical power	1,050,000
Chemical		
	Chlorine	324,000
Maintenance		
	Plant	664,000
	Total	$3,589,000

The total annual operating and maintenance costs do not provide for sludge management. Manpower costs are based on today's labor rates and include fringe benefits. Fuel costs are computed at a unit price of 35.6 cents a gallon and power costs at a unit price of 3 cents per kwh (killowatt-hour). Chemical (chlorine) costs are computed at a purchase price of $205 per ton.

Cost Distribution

One method of assessing the cost of constructing, operating and maintaining a preliminary or secondary wastewater treatment plant is to distribute the costs in accordance with the flow and organic load (BOD_5) and SS load that the plant treats. Such a method is discussed in detail in Technical Data Vol. 12, Financing and Management.

Table 6-4 indicates such a cost distribution for the Nut Island Wastewater Treatment Plant. It is based on an allocation of the elements of cost to each of the three waste parameters for which the treatment process is designed. As in the case of the previous cost tables, no allowance is made for sludge management costs in deriving the distribution set forth in this table.

TABLE 6-4. DISTRIBUTION OF COSTS ON THE BASIS OF WASTE PARAMETERS USED FOR DESIGN

		Percent of total cost		
	Total	Flow	BOD_5	SS
Construction cost				
First phase				
Plant	$45,500,000	77.5	5.7	16.8
Outfall	5,036,000	100.0	-	-
Second phase	86,700,000	21.7	58.8	19.5
Operating and maintenance cost				
First phase	2,027,000	75.5	8.0	16.5
Second phase	3,589,000	37.2	47.6	15.2

APPENDIX A

PRINCIPAL EQUIPMENT

PRINCIPAL EQUIPMENT

Medium Bar Screens	
Number	2
Unit width, ft	7
Bar size, in.	3/8
Clear opening, in.	7/8
Equipment	Mechanically raked
Grit Chamber	
Number	6
Unit width, ft	10.42
Unit length, ft	80
Equipment	One chain and bucket collector per channel One cross grit conveyor
Multiple-Hearth Grit Incinerator	
Number	1
Unit diameter, ft and in.	12-10
Unit height, ft	24
Number of hearths	6
Capacity, tons/day	36
Comminution Equipment	
Number	9
Clear opening, in.	3/8
Unit sizes, in. and capacities, mgd	4 - 36 @ 26 2 - 36 @ 20 3 - 42 @ 40

Main Sewage Pumps

Number	4
Type	Mixed-flow centrifugal
Size, in.	48
Capacity of each, mgd	83.5 @ 10.3 ft discharge head

Flow-Measuring Equipment

Number	1
Type	Venturi meter
Size, in.	120 x 60

Preaeration Tanks

Number	5
Unit width, ft	4 @ 21, 1 @ 12
Unit length, ft	4 @ 166, 1 @ 85
Average sidewater depth, ft	14
Equipment	Swing-arm diffusers

Blowers

Number	2
Type	Positive displacement
Total available capacity, cfm	10,000 cf free air at 8 psig

Primary Settling Tanks

Number	6
Unit width, ft	68
Unit length, ft	185
Average sidewater depth, ft	13

Equipment	Four longitudinal and one cross collector per tank, one scum conveyor per two tanks
Primary Sludge Pumps	
Number	6
Type	Triplex plunger
Unit capacity, gpm	200
Sludge Digestion Tanks	
Number	4
Unit diameter, ft	110
Unit sidewater depth, ft	30
Effective capacity, each, mg	2.3
Effective capacity, total, mg	9.2
Type	Two - fixed covers Two - floating covers
Chlorination Equipment	
Number of chlorinators	4
Unit capacity, lb/day	8,000
Application	Pre- and postchlorination

APPENDIX B

MAIN SEWAGE PUMPS AT NUT ISLAND SEWAGE TREATMENT PLANT

Allen J. Burdoin
CONSULTING ENGINEER

June, 1973

Main Sewage Pumps at

Nut Island Sewage Treatment Plant

Description. Sewage is received from a tributary area of 238.85 sq. miles containing a total population of 778,000 and a sewered population of 618,600 as of the end of 1971. Sewage enters the plant by gravity, flows through bar screens, grit chambers, and comminutors, and is then lifted about 10 ft. to the pre-aeration and sedimentation tanks from which the effluent is discharged by gravity 6000 ft. offshore.

Four vertical mixed flow sewage pumps rated 80 mgd each at 10.3 ft. head at 190 rpm are provided. Two pumps are driven by 200 hp synchronous motors at constant speed, and two by 200 hp wound rotor motors at variable speed. Flomatcher units are provided for speed control. Motors are mounted on and supported by the pumps.

Power is supplied by three engine driven generators, two of which are rated at 750 KVA each and one at 450 KVA. One engine is a straight gas engine; the other two are dual fuel engines. Digester gas is used as fuel.

Sewage Flow vs. Capacity. The sewage flow for the 12 months from July 1, 1971 to June 30, 1972, is compared with the design flow in the following table.

Sewage Flow, mgd.

	min.	av.	max.
Design	——	112	300
Actual	65.7	128.2	188.5

These figures for maximum flow show that the pumps have the capacity to handle present sewage flows with one unit out of service.

Furthermore, the engine driven generators have adequate capacity to supply power to the pumps and other plant equipment, and the production of digester gas is sufficient to supply the needs of the engines with continuous gas wastage through the waste gas burners. This results in substantial savings over what the power would cost if it were purchased.

Age and Condition of Equipment. The pumps are original plant equipment which went into operation in 1952 and are of rugged modern design. Very little maintenance of the pumps as distinct from the drives has been required, and the original wearing rings are still in place. They are said to need replacement. Wear of the rings results in a loss of pump efficiency due to excessive leakage through the rings back to the pump suction. This is not too serious with plant production of power from digester gas unless the situation becomes extreme, in which case, new rings should be installed.

The motors are relatively new, having replaced the 1200 rpm synchronous motors, planetary gears, and magnetic drives originally installed. The original drive units required excessive maintenance, particularly the gears, and their replacement with 190 rpm low speed direct drive motors has resulted in much more dependable units.

The new motors are much heavier than the original motors. They weigh 8 tons and cannot be lifted as a whole by the 5 ton crane. This is inconvenient, since the rotor and stator have to be removed separately to get at the pump interior.

The engine power plant has performed well and with proper main-

tenance should continue to do so indefinitely.

Recommendations. I recommend that each pump be tested individually using plant meters and instruments and the efficiency compared with the original pump curves or test data. If the efficiency loss is greater than 3 percent, the wearing rings should be inspected and replaced if necessary.

I further recommend that a study be made to determine whether the overhead crane and crane runway can be increased in capacity sufficiently to handle the motors as a whole. In the conduct of this study the cooperation of the crane manufacturer should be obtained.

Respectfully submitted,

Allen J. Burdoin

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APPENDIX C

NUT ISLAND WASTEWATER TREATMENT PLANT - INVENTORY

(Note: This appendix to Technical Data Vol. 11 has not been included in all copies of the report due to the nature and length of its content. However, in order to acquaint the reader with its content, the first sheet of the inventory is included. A complete copy of the inventory is available for review at the Metropolitan District Commission, 20 Somerset Street, Boston, Massachusetts.)

Nut Island Treatment Plant
Administration Building

1. Equipment:
   Boilers No. 1 and 2 (for gas or No. 6 oil)

   Location:
   Boiler Room

   Manufacturer:
   Peabody Engineering Corp., New York City
   Dual Fuel Burners, Automatic, Unit Size PK "250", Fully Automatic, Type A Wide, Range Atomizer; Capacity - 162 lb. oil per hour per burner. Oil Supply Pressure 275 psig
   Gas Burner - Ring Type (Fabricated) Capacity - 5200, CFH/Burner, Gas Supply Pressure, 10 psig, Ring drilled with 26 No. 31 dia. holes.

   Flame Detector — Minneapolis Honeywell C7012A Ultra Vision Flame Detector

   PROTECTORELAY - Minn. Honeywell Regulator Co.
   Flame Safeguard Control No. Y479A1021
   Flame Simulator No. 123514A
   Amplifier No. R7253A1014
   Multi-Voltage Model No. R4127A1122

   Motor:
   Fan and Fuel Oil Pump No. 1 and 2
   Nameplate not accessible, data from plant records
   U.S. Electric Motor Inc., Syncrogear
   2 HP, 280 RPM, Ratio 6.18, Type GH, 3 Phase, 60 Cycle, 220/440V, 6/3 A., Motor RPM 1800, Frame No. 224-4-21, SErial No. 1 2050058, No. 2 2000119.

   Controls:
   Local: Normal Boiler controls including,
   Flame Detector by Minneapolis Honeywell
   Protectorelay by Minneapolis Honeywell

   Equipment Condition:
   Boilers installed around 1896 as coal fired, high pressure boilers when plant was only a screening and pumping station. Boilers are derated by inspector to 15 psi. max. pressure due to age. No information on actual condition of tubes or shell, but no obvious leaks. Boiler used mainly for plant heating, and also used for No. 3 sludge heater and effluent heating for